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TECHNICAL NOTE

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G-245-N

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SUMMARY

Spectroscopic analysis of the light produced by electrodeless discharge in a tektite bubble showed the main gases in the bubble to be neon, helium, and oxygen. The neon and helium have probably diffused in from the atmosphere, while the oxygen may be atmospheric gas incorporated in the tektite during its formation.

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This note presents the first results of a new method of determining the composition of gases in tektite bubbles.

Gases in tektites have been reported by Döring and Stutzer,[1] H. E. Suess,[2] J. H. Reynolds,[3] and Gentner and Zähringer.[4] Suess also referred to earlier work by A. Brun. Döring and Stutzer, Brun, and Suess all found CO, CO_2, and H_2. Suess found in addition water, which he considered to have been absorbed in the outer layers of the tektites, and he estimated the gas pressure in a bubble to be less that 10^{-3} atmosphere. Small quantities of argon and neon were detected by Reynolds, and of argon by Gentner and Zähringer. Reynolds measured the diffusion coefficients for australite glass at high temperatures, and showed that if the rates so obtained can be extrapolated to room temperature, the diffusion half-life for neon in a spherical tektite with a 1 centimeter radius would be 1.1 million years; and for helium, 5.6 years.

The present investigation of the gases in a tektite bubble was conducted by subjecting it to an electrodeless discharge. The tektite was bediasite No. 1876 of the U. S. National Museum collection, kindly made available by Mr. E. P. Henderson. The cavity cannot be seen from the outside; it was discovered by Mr. Henderson through its density deficiency, which indicates a bubble whose volume is approximately 0.98 cubic centimeters.

The tektite was placed in the tank coil of an RF oscillator (Figure 1) at the Naval Research Laboratory. The oscillator operates at 96 megacycles; the electric field intensity was about 1.5 kilovolts/centimeter. The tektite lit up after a few seconds, emitting a soft orange glow. It remained cold, however, even after long exposures. There was no detectable change in the intensity or character of the light after repeated excitation.

The light was focussed on the entrance slit of a Meinel airglow spectrograph, kindly loaned by the Rocket Spectroscopy Branch, Atmosphere and Astrophysics Division of the Naval Research Laboratory. After a series of calibration and comparison exposures, the

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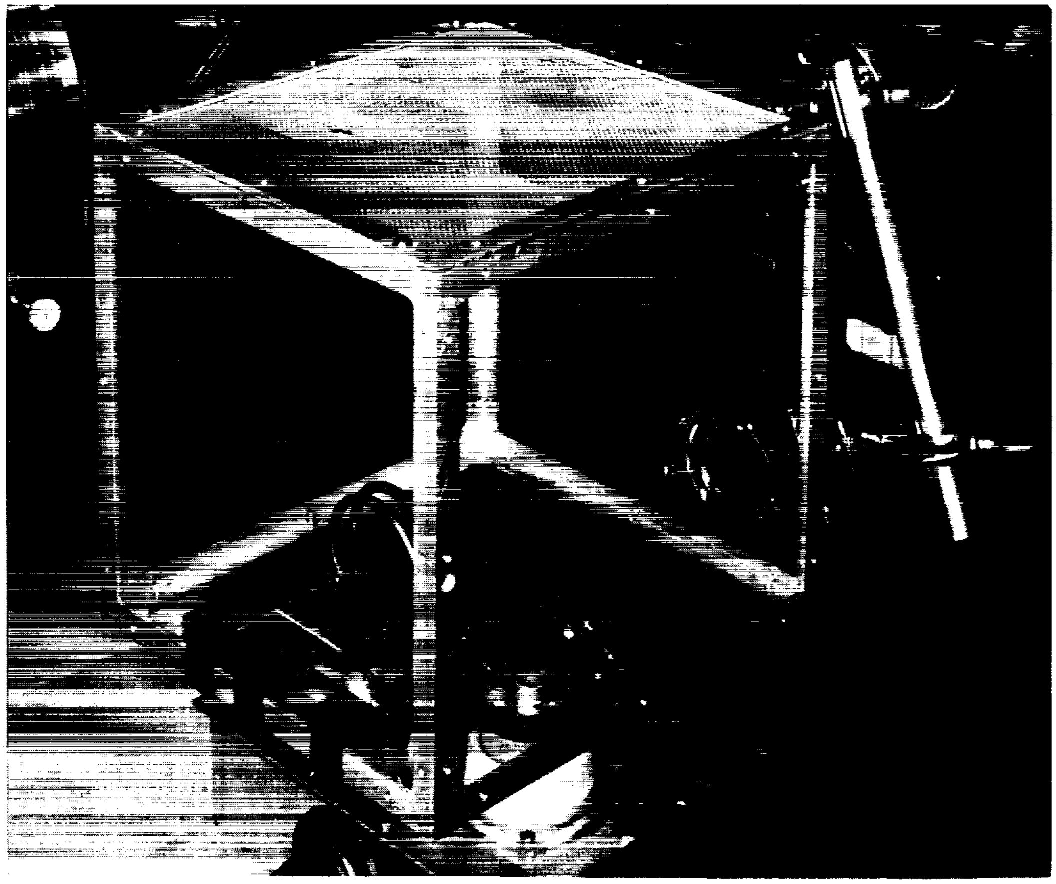

Figure 1a — Plasma exciting apparatus and Meinel spectrograph in operating position

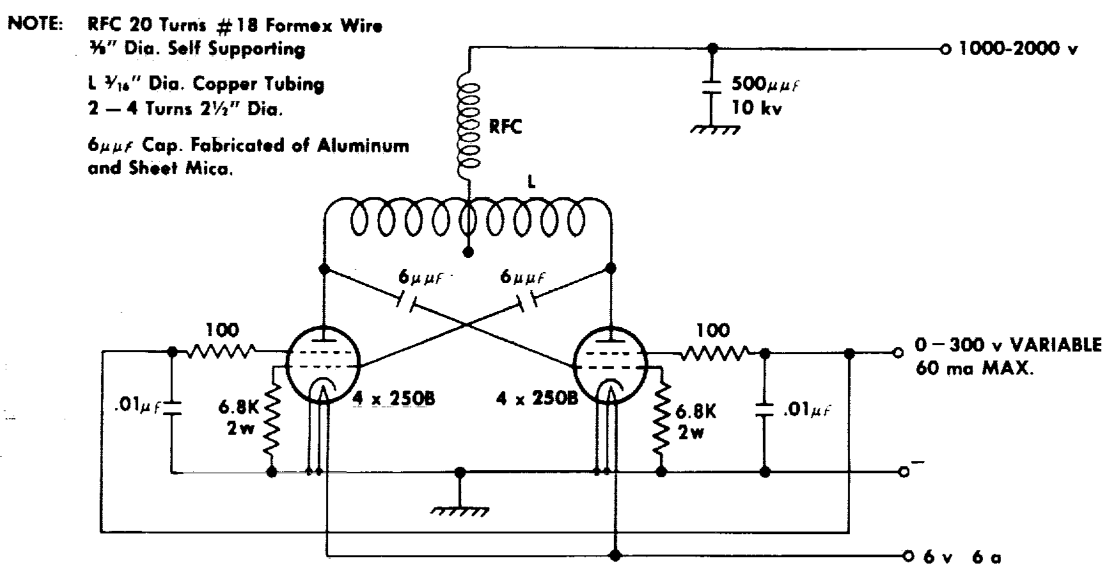

Figure 1b — NRL plasma exciting oscillator spectrograms shown in Figure 2 were taken with exposures of 5(a) and 10(b) minutes on Agfa Isopan Record 35-mm roll film, which was developed for 8 minutes in D-76 at 70°F. The lines were measured with a D. W. Mann comparator, and were identified from the M.I.T. Wavelength Tables compiled by Harrison[5] or from tables of molecular spectra compiled by Pearse and Gaydon.[6] The dispersion of the spectrograph was found to be approximately 150A/mm; dispersion curves were constructed by successive approximations after the strongest lines in the tektite spectrum had been identified by comparison with the spectrum of a neon bulb. Wavelengths used in constructing the dispersion curves are marked in Table 1 with asterisks. Comparison exposures eliminated the possibility that the neon bulb used as a standard was responsible for any lines in the tektite spectrum.

The strongest atomic lines are those of neon (92 found) and helium (12 found). The helium lines found included all but three or four of the He I lines given in the 1960 Handbook of Chemistry and Physics[7] for the region between 3960 and 6400A.

In addition, five lines in the spectrum, the strongest of which is at 4367A, were identified with lines of atomic oxygen. All oxygen lines whose combined intensity in the tables of the Handbook of Chemistry and Physics (based on the M.I.T. Tables) exceeded 150 were either found in the spectrum or explained as lost through blending with neon lines of intensity 1000 or more.

Broad bands, degraded to the violet, were found with heads near 5300 and 5630A, as well as a band in the red, obscured by the strong neon lines, with a head near 6020A. These are identified as contributed by the First Negative[6] system of O_2^+. No lines or bands attributable to argon, hydrogen, or nitrogen were found.

The neon and helium have probably diffused into the bubble from the atmosphere as a result of the high permeability of tektite glass to these gases.[3] This explanation, however, is not possible for the oxygen which may be atmospheric oxygen trapped into the tektite during its formation.

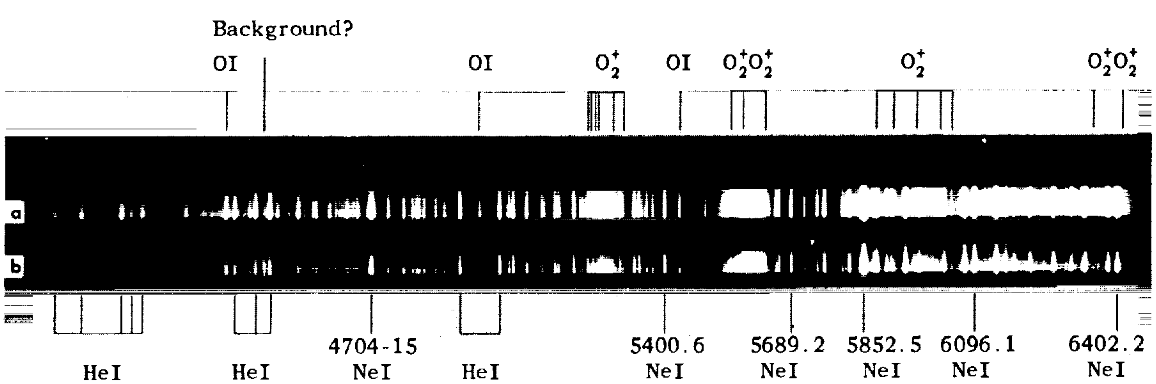

Figure 2 — Enlargements of spectrograms of bediasite No. 1876, film No. Z II. Spectrograms a and b were taken with different focussing conditions.

Table 1

Measured and Published Wavelengths

Element Identified	Measured Wavelength (A)	Published[5] Wavelengths	Estimated Intensity	Published[5] Intensity
Ne I	6402.1*	6402.2	100	2000
Ne I	6382.9*	6383.0	75	1000
Ne I	6334.1*	6334.4	100	1000
Ne I	6305.1*	6304.8	50	100
Ne I	6266.8*	6266.5	100	1000
Ne I	6247.8*	6246.7	10	100
Ne I	6216.7*	6217.3	80	1000
Ne I	6182.0*	6182.2	50	150
Ne I	6163.4*	6163.6	80	1000
Ne I	6142.8*	6143.1	150	1000
Ne I	6126.6*	6128.4	20	100
Ne I	6117.4*	6118.0	20	15
Ne I	6096.0*	6096.2	200	300
Ne I	6074.6*	6074.3	200	1000
Ne I	6047.4*	6046.2	10	50
Ne I	6030.0*	6030.0	100	1000
Band structure	6014.6*			
Band structure or Ne I 6001.0	6004.2*			
Ne I	5989.8*	5991.7 5987.9		75 150
Ne I	5974.6*	5974.5 5974.6		600 500
Ne I	5960.6	5961.6		70
Ne I	5944.4*	5944.8	300	500
Ne I	5914.7*	5913.6	50	250
Ne I	5903.1	5902.4	80	50
Ne I	5881.9*	5881.9	300	1000
He I	5875.4*	5875.6	300	1000
Ne I	5852.5*	5852.5	1000	2000
Ne I	5820.2*	5820.2	100	500
Ne I	5811.8*	5811.4	10	300
Ne I	5804.4*	5804.4	20	500
Ne I	5763.9*	5764.4	200	700
Ne I	5748.4*	5748.3	80	500
Ne I	5719.3*	5719.8 5718.9	40	500 150
Ne I	5689.7*	5689.8	100	150
Ne I	5662.5	5662.5	80	75
Ne I	5654.3*	5656.7 5656.0	140	300 75
Unidentified	5640.1		30	
Band head	5630.8			

*Wavelengths used to determine dispersion as described in the text.

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Table 1 (Continued)

Element Identified	Measured Wavelength (A)	Published[5] Wavelengths	Estimated Intensity	Published[5] Intensity
Band structure	5621.6			
Band structure	5613.4			
Band structure	5603.2			
Band head	5596.6			
Band head	5587.0			
O I	5553.3	5554.9		100
Ne I	5534.5	5533.7 5538.6		75 50
Ne I	5495.9	5494.4	20	50
Ne I	5449.0	5448.5	5	150
O I	5435.9	5435.2	50	70
		5435.8		100
		5436.8		200
Ne I		5433.6		250
Ne I	5420.1	5420.2 5418.6	5	50 150
Ne I	5401.1*	5400.6	200	2000
Ne I	5374.4	5375.0 5372.3	50	50 75
Ne I	5360.8*	5360.0	50	150
Ne I	5342.5*	5343.3 5341.1	80	600 1000
Ne I	5331.4*	5330.8	80	600
Ne I	5316.3	5314.8	5	80
Ne I	5305.7	5304.8		70
Ne I	5298.7	5298.2		150
Band structure	5289.5			
Band structure	5257.5			
Ne I	5279.7	5280.1		50
Ne I	5235.8	5234.0		50
Ne I	5223.5	5222.4		50
Ne I	5211.5	5210.6 5208.9		50 70
Ne I	5205.4	5203.9 5208.9		150 70
Ne I	5190.0	5193.2 5193.1 5188.6	80	150 150 150
Ne I	5155.1	5156.7 5154.4	40	50 50
Ne I	5145.5	5145.0 5144.9	40	500 500
Ne I	5123.0	5122.6 5122.3	20	150 150
Ne I	5115.9	5116.5 5113.7	20	150 75
Ne I	5103.9	5104.7	5	35
Ne I	5080.7	5080.4	80	150

*Wavelengths used to determine dispersion as described in the text.

Table 1 (Continued)

Element Identified	Measured Wavelength (A)	Published[5] Wavelengths	Estimated Intensity	Published[5] Intensity
He I	5047.5*	5047.7	100	15
Ne I	5038.5*	5037.8	40	500
He I	5016.0	5015.7	200	100
Ne I	4995.4	4994.9	10	150
O I	4969.7	4967.4 4967.9 4968.8	10	50 80 100
Ne I	4957.3	4957.0	10	1000
Ne I	4947.3	4945.0	10	100
Ne I	4939.4	4939.0	10	100
He I	4922.2*	4921.9	100	50
Ne I	4892.9	4892.2 4892.0	10	10 500
Ne I	4885.1	4885.1 4884.9	30	100 1000
Ne I	4865.4	4865.5	25	100
Ne I	4852.3	4852.7 4851.5	10	100 60
Ne I	4837.8	4837.3	40	500
Ne I	4824.6	4827.3 4825.5 4823.2	30	1000 50 100
Ne I	4811.0	4810.6 4810.1	20	100 150
Ne I	4789.6	4789.6 4788.9	30	100 300
Ne I	4782.0	4780.3 4780.9	5	50 30
O I	4773.5	4773.8 4772.9	10	70 50
Ne I	4751.7*	4752.7	50	1000
Ne I	4712.3	4680.4**	30	100
Ne I	4679.5	4679.1	20	150
Ne I	4669.7	4667.4 4670.9	20	100 70
Ne I	4656.2	4656.4	20	300
Ne I	4636.8	4637.0 4636.6	5	50 70
Ne I	4628.2	4628.3	20	150
Ne I	4613.4	4614.4	20	100
Ne I	4593.4	4593.2	5	50
Ne I	4581.7	4582.4 4582.0	20	150 150
Ne I	4573.9	4575.1	20	300
Ne I	4553.6	4553.2	5	50
Ne I	4538.9*	4537.8	30	1000
Ne I	4525.3	4525.8	5	70

*Wavelengths used to determine dispersion as described in the text.

**Strong neon lines at 4715.3, 4712.1, 4710.1, 4708.9, 4704.4 all over 1000.

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Table 1 (Continued)

Element Identified	Measured Wavelength (A)	Published[5] Wavelengths	Estimated Intensity	Published[5] Intensity
Ne I	4516.1	4516.9 4517.7 4514.9	10	50 ? 70
Ne I	4489.1	4488.1	40	300
He I	4469.6	4471.5	100	100
Background, prob. scattered light	4456.6		50	
He I	4437.5*	4437.5	40	10
Ne I	4424.8	4424.8	30	300
He I	4386.8*	4387.9	50	15
O I	4367.3	4368.3	50	1000
Ne I	4334.1	4334.1	5	70
Ne I	4314.8	4314.7	5	30
Ne I	4272.1	4268.0 4269.7 4270.2 4274.7 4275.6	10	70 70 50 50 70
He I	4169.1*	4169.0	10	7
He I	4144.0*	4143.8	10	15
He I	4121.4*	4120.8	20	25
He I	4026.1	4026.2	5	70
He I	3964.5	3964.7	3	50

*Wavelengths used to determine dispersion as described in the text.

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